# Experimental Plant for Resource Recovery

## REPORT ON PLANT OPERATIONS

APRIL, 1978 - SEPTEMBER, 1979



Ministry of the Environment
Ontario

The Honourable
Keith C. Norton, Q.C.,
Minister

Gérard J. M. Raymond
Deputy Minister

# EXPERIMENTAL PLANT FOR RESOURCE RECOVERY

## REPORT ON PLANT OPERATIONS

## APRIL, 1978 - SEPTEMBER, 1979

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Ontario Ministry Of Environment

Waste Management Branch

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## INTRODUCTION

The Experimental Plant for Resource Recovery (ERRP), a $15,000,000 facility which serves as the cornerstone of the resource recovery aspect of the Ontario Ministry of the Environment's waste management program, operates to fulfill the following principal objectives:

1. To develop and evaluate processes and equipment for resource recovery;

2. To develop criteria for design and for estimating capital and operating costs; and

3. To provide a regular supply of recovered materials for product utilization and market development.

General management of research programs within the plant and market development activities for plant products are provided by the Waste Management Branch of the Ministry of the Environment.

Operation and direct management of the facility is provided on a contractual basis, currently by Browning-Ferris Industries Ltd. of Toronto, under terms of a five year agreement.

Through an agreement with Metropolitan Toronto, general municipal solid waste, as collected from residential and commercial sources, is directed to the facility. Metropolitan Toronto staff operate the scalehouse which serves both the Experimental Plant and the nearby Dufferin Incinerator.

This report reviews the performance and operating costs of the ERRP for the period April 1978 to September 1979 inclusive. During this period, the waste transfer facilities, placed into operation in March 1977 continued in routine daily operation. Baling operations, including the production of baled corrugated cardboard and source-separated waste newspaper, also continued on a routine basis. The corrugated recovery system was modified in September 1979 to improve production.

Construction of the resource recovery processing facilities was completed in April 1978 when this portion of the plant was turned over to Browning-Ferris Industries for final shakedown and startup. The composting system was completed in June, 1978. This report deals primarily with the shakedown and startup phase of the resource recovery facilities and the operational and equipment modifications required during the first eighteen months in improving the overall efficiency to establish normal operations. Because of the nature of operations during this period, meaningful data representative of unit operations performance and operating and maintenance costs under normal conditions are not available. However, outstanding aspects in these areas are reviewed.

On August 1, 1978, the Experimental Plant for Resource Recovery was officially opened by the Honourable William G. Davis, Premier of Ontario.

## PLANT DESCRIPTION

The Experimental Plant for Resource Recovery is designed to receive general municipal solid waste as collected from residential and commercial sources in the Metropolitan Toronto area. The plant, located on a 17 acre (7 hectare) site in North York, Metropolitan Toronto, comprises the following features: scalehouse; receiving/transfer/paper recovery building; shredding and air separation/classification building; commodity and energy recovery building; and composting building. A more detailed description of the $15.0 million facility is available elsewhere (1). An architectural sketch and a process schematic for the plant are shown in Figures 1 and 2 respectively.

A listing of the contractor's operating and management staff is presented in Table 1. A total of four Ministry staff are involved in research activities at the plant.

**RESOURCE RECOVERY**
**ONTARIO MINISTRY OF THE ENVIRONMENT**

**EXPERIMENTAL PLANT
FOR RESOURCE RECOVERY
NORTH YORK, ONTARIO**

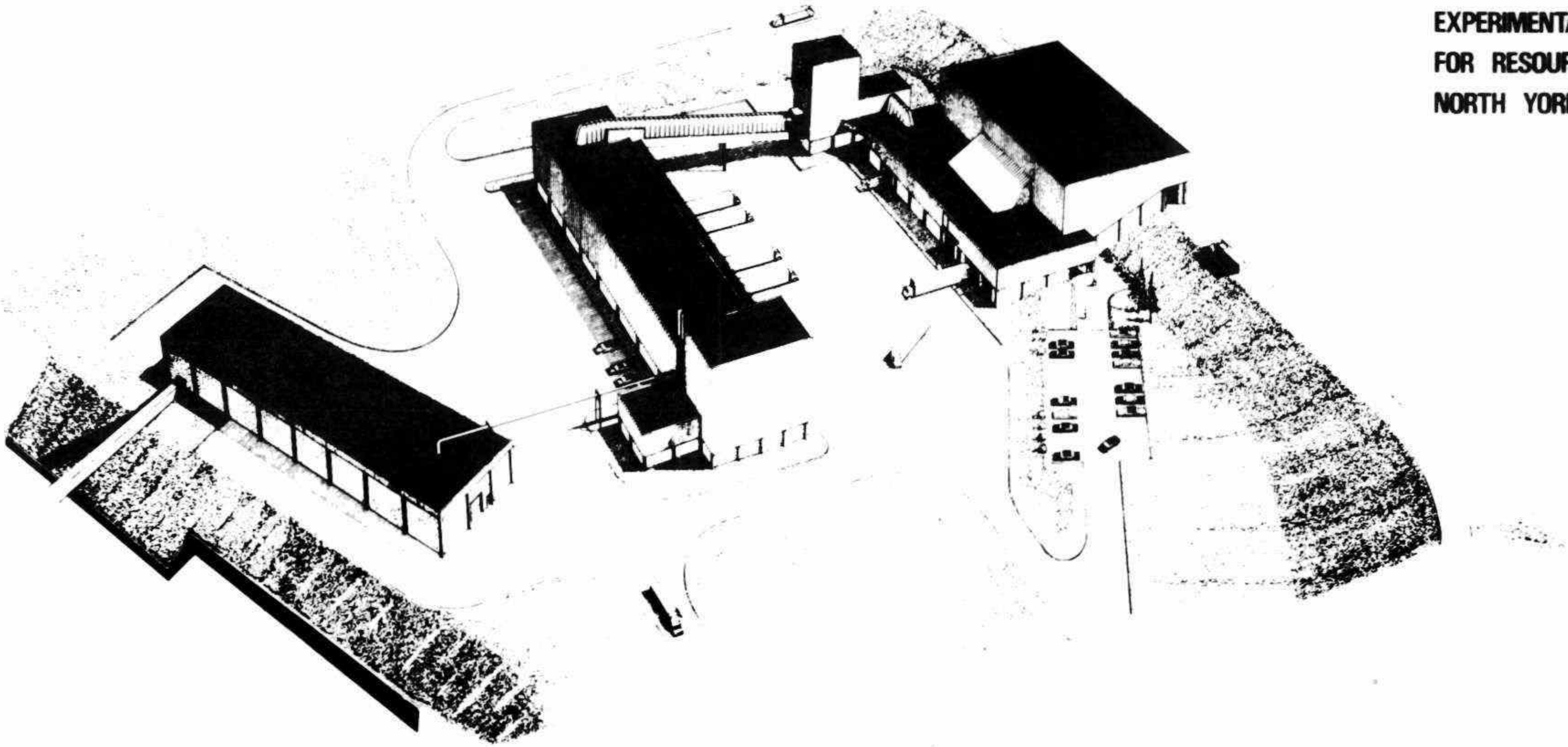

Fig. 1

**RESOURCE RECOVERY**

**ONTARIO MINISTRY OF THE ENVIRONMENT**

**EXPERIMENTAL PLANT FOR RESOURCE RECOVERY**

**PROCESS FLOW DIAGRAM**

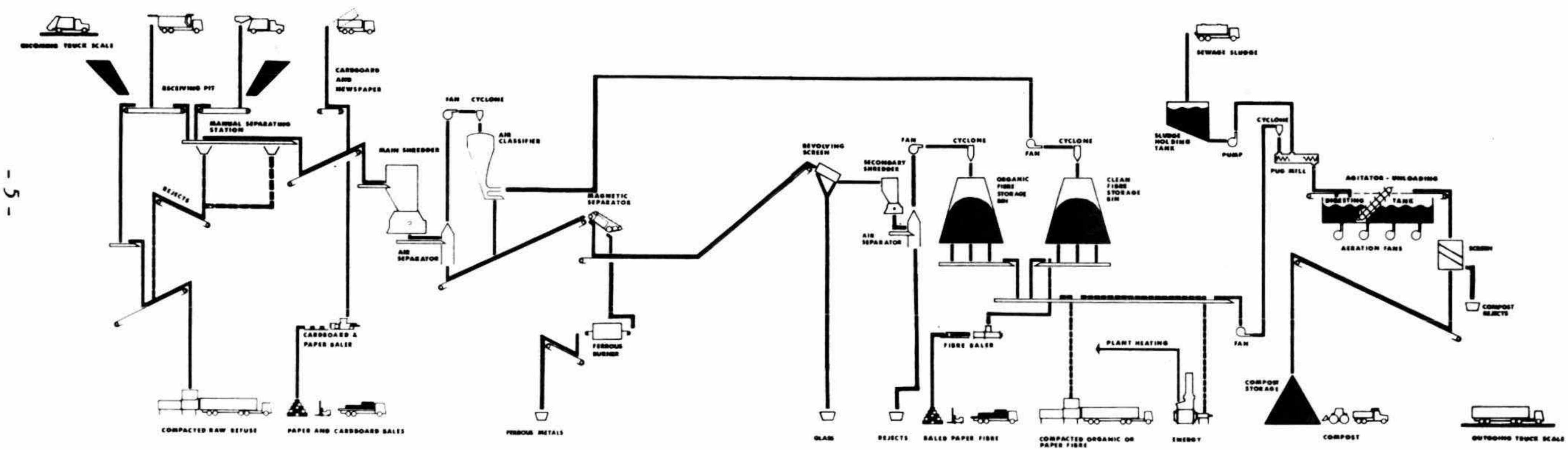


Fig. 2

## TABLE 1

## OPERATING AND MANAGEMENT STAFF

| | |
|---|---|
| Administrative and Supervisory | General Manager<br>Plant Supervisor<br>Secretary |
| Transfer | Foreman (Area 300) (common to transfer and resource recovery)<br>Front end loader operator (common to transfer and resource recovery)<br>Control room operator<br>Compactor room operator<br>Utility operator |
| Resource Recovery | Foreman (Area 500)<br>Receiving floor spotter (common to transfer and resource recovery)<br>Control room operator - Area 300, 400<br>Control room operator - Area 400, 500<br>Storage-loadout operator<br>Baler operator<br>Solid Waste Fired Incinerator Operator<br>Mobile Equipment Operator<br>Utility Operator - manual inspection and corrugated recovery - (2)<br>Composting Operator<br>Utility Operator - (2) |
| Corrugated Recovery | Baler Operator<br>Utility operator - corrugated recovery (3) |
| Maintenance | Maintenance Foreman<br>Night Maintenance Foreman<br>Electrician<br>Mechanic (2)<br>Mechanics Helper (3)<br>Lubrication man |

## WASTE RECEIPTS

Incoming waste loads are weighed at the ERRP scalehouse, operated by Metropolitan Toronto staff, and are directed to either the Dufferin Incinerator (owned and operated by Metropolitan Toronto) or the Experimental Plant. Residential waste is directed preferentially to the Dufferin Incinerator which can not process the commercial/industrial wastes which constitute the majority of the Experimental Plant's waste receipts. All billing of private waste haulers is the responsibility of Metropolitan Toronto; the Ministry of the Environment receives a tipping fee from Metropolitan Toronto for the tonnage received by the ERRP.

During the period April 1978 to September 1979 inclusive, wastes were received on each of the 377 operating days. A total of 209,371.93 tonnes of waste were received. Of this, 17% was collected by municipal vehicles; the remainder of the waste was collected by private waste haulers. Daily waste receipts ranged from 284.21 to 1011.45 tonnes. Average daily waste receipts were 555 tonnes. Seasonal variations in waste receipts were observed but were somewhat obscured by several changes in the gross load limit (maximum allowable gross truck weight) during the period considered. The average incoming waste load during this period weighed 3.66 tonnes.

In Figure 3, the monthly waste receipts for the eighteen months considered in this report are presented. The waste receipts for the first year of operation are also shown for comparison.

In Figure 4, the average daily waste receipts with the minimum and maximum day are shown.

During the eighteen months of operations considered here, a total of 161 violation notices were issued to waste haulers for prohibited materials in the incoming wastes. Of these, 37% of the violation notices were issued for excessively dusty material, 21% for sawdust, 12% for construction debris, 5% for paint, and the remainder for miscellaneous reasons including excessively long material, wire, liquid filled 45 gallons drums, and disregarding speed limits, signs, or operator's directions. Appendix 1 is a list of prohibited materials considered hazardous or giving rise to material handling problems; this list was established by the Municipality of Metropolitan Toronto.

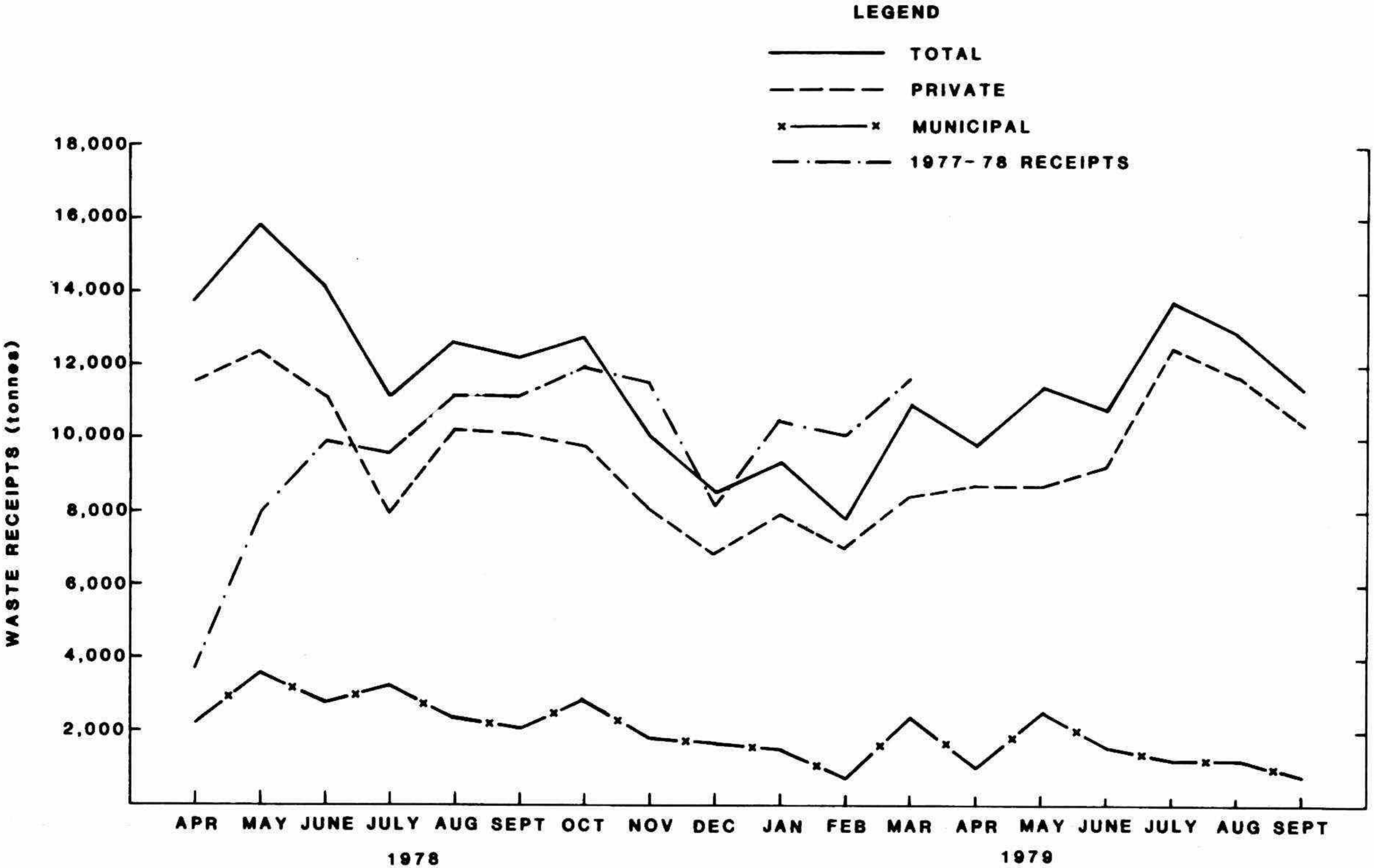


Fig. 3 - Monthly Waste Receipts

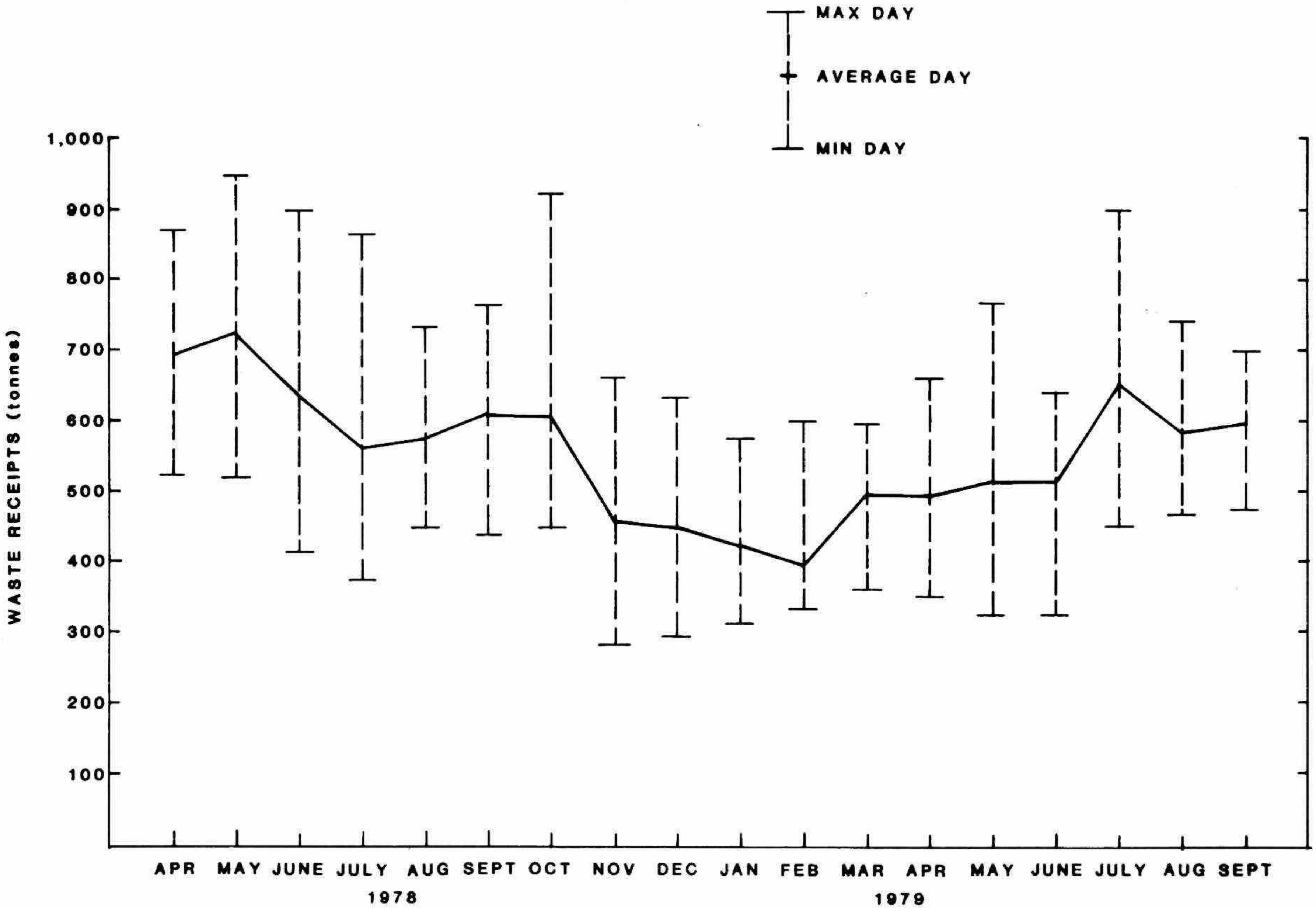


Fig. 4 - Average Daily Waste Receipts

One particular problem in the receiving area has been trucks being in collision with the exit door. In all cases, trucks have attempted to leave the building with a portion of their equipment in an elevated position, striking the raised exit door. The width of the door is generally adequate but a much higher opening to accommodate driver errors would be desirable. Attempts to protect the door with elevated barriers have only resulted in greater damage to both the building and trucks.

The total receiving area of the Experimental Plant is comparatively small, 1000 $m^2$, for the design tonnage (800 tonnes per day). The usable floor area excluding the manoeuvering area for trucks and the front end loader, the corrugated recovery area, and clear lanes beside the outside walls is further reduced to approximately 600 $m^2$. A layout of the receiving floor is illustrated in Figure 5.

The direct dumping feature of the receiving and transfer operation has proven that the receiving area has been adequate in processing up to 1000 tonnes of waste per day. Arrival patterns for private waste haulers are more consistent throughout the day than for municipal vehicles; a larger storage area or a change in arrival patterns would likely be necessary to achieve the same success for a municipal operation which is normally characterized by several peak arrival periods.

The provision of numbered and marked lanes for direct dumping has not proven to be of particular benefit. Once material has been discharged onto the receiving apron conveyor, additional dumping on the conveyor must be between that load and the conveyor tail pulley. Consequently direct dumping for the transfer operation has been limited to a two to three lane area near the apron conveyor tail pulley where a constantly renewed empty conveyor is available. The original lane lights intended to direct truck drivers to an appropriate lane are now used strictly by the operator to indicate to the spotter or the front-end loader operator, the two staff involved in waste receipts, when and where to load the conveyor.

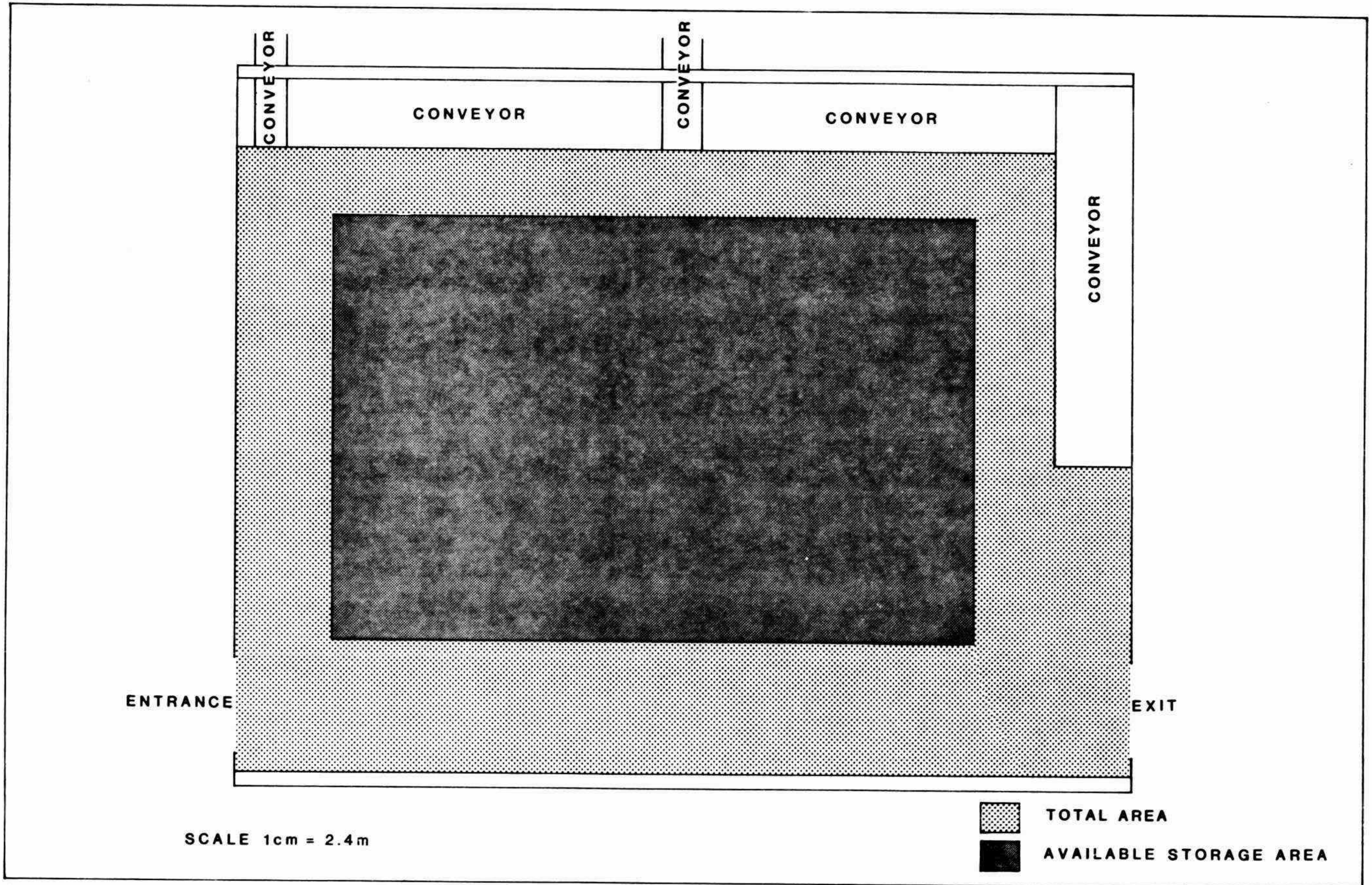


Fig. 5 - Receiving Floor Layout

Results of a dust monitoring survey conducted in the receiving-transfer and paper recovery area of the plant during January to March 1978 were received during the period of this report. Personal samples for four BFI staff and high volume samples in two areas were collected and analyzed for mass loading, lead, mercury, cadmium and respirable free silica. In each instance, the levels found were below the threshold limit values recommended by the American Conference of Governmental and Industrial Hygienists for 1977 (2). Particulate polycyclic aromatic hydrocarbons, defined as benzene solubles, were above the recommended level in the recovery area, but analysis for individual polycyclic compounds showed that such compounds accounted for only a small portion of the benzene soluble materials.

While the wearing of personal protective equipment for potential hazards from dust and noise is not mandatory, such equipment is made available and its use encouraged. Additional surveys for occupational health hazards will be undertaken in the future.

## TRANSFER OPERATIONS

### Operation

The transfer facilities of the ERRP were operated on each of the 377 operating days during the period April 1978 to September 1979 inclusive. A total of 11,797 transfer loads of waste, weighing 204,488.76 tonnes, were hauled to landfill. The average transfer payload was 17.33 tonnes. Excluding the waste receiving operations, three BFI staff operate the transfer loadout facility.

Downtime from operating problems on the 377 days (3016 hours) totalled 267 hours; the transfer operation availability was therefore 91%. Additional downtime of 191 hours occurred as the result of the lack of available transfer vehicles. Idle production time of 77 hours resulted from a lack of garbage.

The air curtain doors installed early in 1978 to provide a heated air barrier around the transfer vehicles, which are half outdoors when being loaded, have been in operation through a full winter. They have been able to provide acceptable working conditions for the transfer loadout operating staff.

There were nine fires associated with the receiving-transfer operation in the period considered here; two in materials stored on the receiving floor, two on conveyors, one in an incoming waste load, and four in transfer vehicles. None of these fires resulted in major damage.

### Problems

A mechanical breakdown of the inclined apron conveyor in July 1978 resulted in the need to store waste on the receiving floor. A total of 478 tonnes were stored until the following day; this is the maximum quantity of waste ever stored on the receiving floor and establishes a known storage capacity. It appeared at the time that some additional wastes could be stored; the maximum practical storage capacity is estimated at 600 tonnes. The need for waste storage occurs only in the event of a mechanical breakdown of key pieces of equipment such as the vibrating conveyor, the inclined apron conveyor, or both compactors simultaneously. Since the transfer facilities were placed in routine operation in 1977, there has not been a need to stop waste receipts because of the lack of availability of either the equipment in an operational state or

temporary storage space for waste while equipment repairs were being effected. There was concern originally that the downtime of the conveyor systems, on which loadout is totally dependent, would be great enough to require the occasional stoppage of waste receipts.

The inclined apron conveyor has been the source of most of the maintenance in the transfer operation; the original gear box has been replaced and the moving parts of the conveyor require frequent maintenance. A steel apron conveyor is best suited to the severe duty but a wider conveyor of slower speed would likely have reduced the maintenance requirements. The other conveyors have required periodic maintenance consistent with the severe duty.

The bottoms of both compactors have had to be replaced because of distortion from the impact load of material dropping approximately 5 m directly from the bottom of the diverter gate (approximately 8 m from the inclined conveyor head pulley). The bottoms were replaced with a more impact resistant steel early in 1979 after approximately 22 months of operation.

Based on the actual equipment operating time and tonnage processed through transfer, the average material handling rate during the period considered was 82 tonnes per hour. The vibrating conveyor between the two apron conveyors is considered to be the limiting factor in this rate although material handling problems from the commercial-industrial waste processed is also a negative factor.

Vibration problems from the vibrating conveyor have been overcome to the extent practically feasible by modifying the support and by dynamically balancing the conveyor, but the nuisance aspects of vibration remain. The initial vibration problem with the vibrating conveyor was lessened by increasing the mass of the conveyor support base and adding a stiffening wall to the supports. The initial problem was apparently worsened by the fact that the supports were perpendicular to the direction of flow rather than parallel to it. However, vibration problems were not brought to an acceptable level until the conveyor was dynamically balanced.

The vibrating conveyor has been a major source of material handling problems in the transfer operation. Measurements of the velocity for material that moves in a typical manner were found to be approximately 64 percent of the design velocity of 15m/minute at the conveyor's design stroke of 25.4mm Many

other materials moved so poorly that meaningful velocity measurements were not practical. Such materials included cardboard, foam, and other light materials which apparently were able to absorb the impact from the conveyor rather than it being converted into horizontal motion.

Because of both the material handling problems and vibration problems, the use of vibrating conveyors in this application in future would not be considered practical. In the Experimental Plant, the ninety-degree bend in the material flow further worsens the material handling difficulties in the transfer conveyor system. The reversing feature of the receiving apron conveyor must frequently be used to clear material jams at the vibrating conveyor.

Long pieces of material originally moved poorly on the inclined apron conveyor. The addition of flights to this conveyor improved the handling of such materials and also improved the performance of the vibrating conveyor by rapidly removing material from its discharge.

A preferred layout for the transfer operation would avoid the use of vibrating conveyors, minimize the need to elevate waste fed to compactors both to avoid compactor impact loads and material handling problems on conveyors, and avoid changes in material flow direction. Provision for direct dumping into the compactors (or one compactor) may be considered but the availability of equipment in the Experimental Plant to date has indicated that this feature would seldom be required.

**Operating and Maintenance Costs**

For the eighteen month period, April 1978 to September 1979, the total operating costs for the transfer station portion of the Experimental Plant were $254,125.44. Table 2 provides a breakdown of this total operating expenditure.

## TABLE 2

## TRANSFER STATION OPERATING COSTS

April 1978 to September 1979

| | Costs | \$/ tonne Transferred |
|---|---|---|
| Wages and benefits | \$108,195.05 | 0.53 |
| Operating Supplies | 14,065.75 | 0.07 |
| Electricity | 27,625.07 | 0.13 |
| Outside Services | 1,694.15 | 0.01 |
| Allocated Expenses | 87,063.88 | 0.43 |
| Total | \$238,643.90 | \$ 1.17 |

The \$108,195.05 expenditure includes all wages paid, including fringe benefits, to the four operating staff involved with the transfer function. These included the receiving floor front-end loader operator, the transfer control cab operator, a floor compactor operator, and a utility man. For accounting purposes, the receiving floor spotter was charged to the resource recovery operation, thus recognizing the shared cost of the receiving floor staff between transfer and resource recovery.

As expected, maintenance department services, "Allocated Expenses", comprised the second largest expenditure item. Table 3 provides a breakdown of these maintenance expenditures.

## TABLE 3

### TRANSFER STATION MAINTENANCE COSTS

April 1978 to September 1979

| | |
|---|---|
| Plant Maintenance and General Service | $ 37,060.46 |
| Compactors | 10,887.62 |
| Receiving Apron Conveyor | 12,858.98 |
| Vibrating Conveyor | 1,958.82 |
| Inclined Apron Conveyor | 17,074.51 |
| Mobile Equipment | 5,608.13 |
| Miscellaneous | 1,618.36 |
| TOTAL | $ 87,063.88 |

The plant maintenance category includes the numerous expenditures for repairs to the exit door for the receiving floor.

As indicated in Table 2, the unit cost of the transfer station operation for this time period was $1.17 per tonne of waste transferred. Similarly, the hourly cost of operation was $79.13. With adequate waste receipts allowing operation at a rate of up to 90 tonnes/hr, the unit operating costs would have approached $1.00 per tonne transferred.

The cost of hauling 204,488.76 tonnes of waste over the period April, 1978 to September 1979 was $1,499,753 or $7.33 per tonne hauled. Total cost of refuse transfer and haul was then $8.50 per tonne, excluding capital facility costs.

## PAPER RECOVERY OPERATIONS

Paper recovery operations at the Experimental Plant include the baling of corrugated cardboard manually separated from waste receipts and the baling of source-separated waste newspapers collected by Metropolitan Toronto. The handling of waste news is performed as a service for Metropolitan Toronto. Baling of other materials, such as fine paper, has been done on a trial basis for marketing purposes. A summary of the materials handled is shown in Table 4.

**TABLE 4**

**PAPER BALING**

April 1978 - September 1979

| MATERIAL | SHIPMENTS | | |
|---|---|---|---|
| | LOADS | BALES | TONNES |
| Corrugated Cardboard | 82 | 2233 | 1244.56 |
| Waste Newspaper | 290 | 7679 | 5115.37 |
| | 4 | ---- | 72.95 * |
| TOTAL | 376 | 9912 | 6432.88 |

*shipped loose

As much of the total corrugated in waste receipts was being lost for the lack of an effective means of recovery, the cardboard recovery system was modified in September 1979. Originally personnel manually sorted cardboard from a pile of waste beside a belt conveyor feeding the baler. This method of recovery was not particularly effective because the accessibility of cardboard was restricted to the edge of the pile of material. The pile had to be frequently turned by the front end loader and personnel had to move constantly between different areas of the pile and the conveyor belt resulting in much wasted effort. Personnel were also exposed to vehicular hazards and ambient weather conditions on the receiving floor. These constraints limited corrugated production to an average 70 tonnes per month.

The new corrugated recovery system features an additional conveyor, fed from the shortened original cardboard recovery conveyor, from which cardboard is manually sorted as the waste stream is fed past personnel stationed beside the conveyor. Recovered cardboard is deposited on another new conveyor returning recovered material to the baler. A bypass chute allows material to be fed directly to the baler from the original receiving floor conveyor. This is used when baling newspaper or when it is necessary to temporarily revert to the original cardboard recovery system.

The installation of the new system was completed in September 1979. An immediate increase in production resulted and further increases are anticipated when some minor modifications are completed.

A factor that must be recognized in considering a corrugated recovery system is that the cardboard itself must be present in sufficient quantities to warrant recovery. At the ERRP, wastes received are predominantly commercial and industrial and these types of wastes can be considered to contain between 5% and 10% cardboard on a gross tonnage basis. However, since these types of wastes comprise approximately one-half of a municipal solid waste stream, it appears reasonable to conclude that such recovery systems should be incorporated into the design of transfer stations or resource recovery facilities handling mixed municipal refuse as opposed to strictly residential.

The operating costs of the paper recovery operation are shown in Table 5.

**TABLE 5**

**PAPER RECOVERY OPERATING COSTS**

April 1978 - September 1979

| | |
|---|---|
| Wages and benefits | $ 68,323.16 |
| Operating Supplies | 21,228.60 |
| Electricity and Fuel | 16,050.57 |
| Allocated Expenses | 20,395.09 |
| TOTAL | $125,997.42 |

Wage expenditures for the paper recovery operation include all wages paid, including fringe benefits, to the four staff involved, i.e. a baler operator and three corrugated pickers. The purchase of baling wire is the major expenditure within the operating supplies category. Major maintenance expenditures (Allocated Expenses) were for the double piston baler, $6,803.96, and for all plant fork lifts, $7,981.20.

Corrugated recovery during this period totalled 1,244 tonnes with an associated revenue of $90,600. The 5,118 tonnes of waste news baled for Metro Toronto had a corresponding revenue of $51,880 thus yielding a total revenue for the paper recovery operations of $142,480. It should be noted that no tipping fee credit has been taken for the cardboard tonnage recovered nor has the intangible saving in disposal costs been considered.

## RESOURCE RECOVERY OPERATIONS

Responsibility for the resource recovery facilities was assumed by Browning-Ferris Industries (BFI) on behalf of the Ministry on April 19, 1978. The composting operations were incomplete at this time and were not considered as part of BFI's responsibility until June, 1978. Most of the time period considered in this report was involved in the plant shakedown and startup to achieve normal operations.

Total BFI staff involved directly in the resource recovery operations numbers 13, including the foreman and the operators for the solid waste fired incinerator and the composting system. This includes the foreman and receiving floor spotter common to the transfer, paper recovery, and resource recovery operations in the receiving building.

The responsibility for construction completion and commissioning, originally with the contract management consultant, was ultimately assumed by the Ministry and BFI. All major construction was completed under terms of the construction contract but modifications were undertaken by BFI during commissioning when the construction crews were still on site. BFI assumed control of operations with many outstanding deficiencies and the need for many modifications identified. It is felt that this approach shortened the shakedown phase by eliminating the need to negotiate change orders with the construction contractor and to co-ordinate all of these changes and plant operation with BFI staff. Because some of the problems were of a material handling nature previously encountered by BFI in other operations, the modifications, such as the design and installation of conveyor skirting and chutes, were more readily undertaken by BFI. This also served to train new BFI staff to handle similar problems elsewhere in the plant when they manifested themselves as a result of increasing processing rates. The cost of modifications undertaken by BFI through service contracts were generally lower than obtained through the original contractor, likely because the work was being considered as an entity in itself rather than as an addition to the original contract. Most of the retrofitting undertaken through external contracts involved large capital expenditures (replacement of conveyor, additional equipment) or was beyond the scope of BFI's normal maintenance capabilities.

It should be recognized that a number of large capital expenditure retrofit items will likely be encountered during the startup and shakedown phase of a waste processing facility. A supplementary capital fund should be made available to expeditiously deal with such items as they occur; for the ERRP this fund was $0.5 million. Effective use of this fund requires co-ordination with all parties involved in the design and operation of the facility, i.e. the consultant, contractor, operator, and owner.

**Shakedown**

The delays and equipment modifications encountered during shakedown and startup were not unexpected; in any new industrial facility such problems are considered normal. The time taken to overcome such problems in the Experimental Plant was longer than originally anticipated for several reasons including the length and complexity of the processing line and controls, the general lack of background information in operating this type of facility, the lack of experience of operating staff, and problems with explosions and fires.

Many of the early start-up delays were directly attributable to equipment problems of a type that would not even permit operation. For example, the air classifiers would not work at all, resulting in repeated material jams, and underwent modifications almost immediately. Gear boxes for the composting system had to be repaired as soon as they were tested. The solid waste fired incinerator as well as its feed and ash removal systems presented many mechanical and control problems. Electronic controls for the main processing line as well as for other pieces of equipment, such as the baler, required repairs and modifications or both. Instruments, such as the weigh belts, had to be calibrated. The need for additional instrumentation for meaningful process control was identified; for example, direct readout of the two air separator air flows. False activations of smoke detectors by dust, because they were not suited to the application, caused delays until the units were removed from service.

When the original construction company was still on site or when it was the logical contractor because of past familiarity with the equipment, it was retained to undertake modifications during plant shakedown. Some modifications were undertaken through the original equipment supplier; for example, dynamic

balancing of the vibrating conveyor which receives material from the receiving floor apron conveyor. As in the transfer operation, this modification was undertaken to minimize vibration transmission to the building rather than to improve material flow.

### Start-up

Most of the major production related problem areas were identified by September, 1978, the first month in which the resource recovery facilities processed waste on each of the operating days. By the end of November, 1978, action had been taken on most problem areas and the plant operation could be considered routine as far as system operation was concerned, with the exception of the daily production rate. The daily production goal of 200 tonnes per day ultimately was achieved in July, 1979. The explosions in December, 1978 and April, 1979, the primary shredder motor repair, and the operation in March and April, 1979 without one of the fibre storage bins because of the failure of one of the slipstick conveyor drives all adversely affected the time required to repeatedly achieve the daily production goal.

Identification of problems during shakedown and start-up was complicated by the lack of experience of operating staff. Some of the initial problems, such as recognizing that a material jam was developing, were inevitably worsened by this lack of experience. The method of dealing with the problem also took much longer than when routine conditions were finally achieved, because the nature of the problem and how to deal with it were frequently unknown by the staff directly involved. The initial severity of some of the material handling problems also led to an understandable reluctance of operating staff to test the system to its limits following a modification, thereby resulting in further delays in achieving the plant capacity. On the maximum production day during the period April, 1978 to September, 1979, 239 tonnes of waste were processed. The month with maximum production was July, 1979, in which 3,141 tonnes were processed.

### Primary Shredder

The primary shredder is the key piece of equipment for the resource recovery operation. The primary shredder has been trouble free with respect to the shredding of wastes for which it was designed; the July 1979 monthly average of 37.7 tonnes per hour for twenty-one days of operation, exceeded the design

rate (36 tonnes per hour), while for six days of operation in August 1979 the average rate was 47.4 tonnes per hour. Problems resulted from shredding of materials such as carpets, heavy metals, or wastes containing organic solvents. Shredding of a carpet resulted in a jam of the unit requiring most of a day to manually clear. Internal liners of the shredder have been destroyed when retaining nuts worked loose from vibration; a thorough maintenance programme is required to avoid such problems. At times the feed has had to be stopped to remove heavy metal from the shredder (normally from the shredder feed conveyor when the metal is thrown out of the shredder). These large pieces of metal, overheated by the shredding action, have been a major source of fires. Wastes containing solvents are believed to be the cause of the three explosions associated with the primary shredder in the first eighteen months of operation. Explosions are an operating hazard for which there appears to be no effective preventative measure. In the Experimental Plant, action has been concentrated on minimizing damage in the event of an explosion, recognizing that such incidents are inevitable. This action included studies of alternatives to minimize damage, studies on hydrocarbon and dust concentrations in the shredder feed area, and finally, the installation of shredder vents and an external baghouse exhaust combined with continuous baghouse operation. Hydrocarbons continue to be of concern but there appears to be little likelihood of a dust explosion. Further details of loss control measures for the primary shredder are available elsewhere (3). Details of fires associated with the shredding operation are available in this same reference. A June, 1975, modification to the edge of the shredder rotor end discs to cause them to act as fans to sweep internal areas of the shredder clear of fine debris has virtually eliminated the fire problem. There were 14 fires associated with the shredder in the two months preceding the modification and none in the six weeks of operation considered in this report following the modification.

Much of the downtime in the first eighteen months of operation was due to problems with the primary shredder motor. The motor underwent a temporary repair in July 1978 following a problem with one of the phases overheating. A complete overhaul of the motor, requiring its complete disassembly, had to be undertaken in August, 1979 because of a recurrence of the high temperature problem in the windings. Both of these problems may have resulted from a contractor's disassembly and improper re-assembly of part of the motor during

its storage on site prior to initial installation. It would appear advisable to have large motors thoroughly checked mechanically and electrically before being operated.

**Air Separation**

The primary air separation system is one of the most important separation processes in the resource recovery system, the light fraction recovered by this process representing the principal product and therefore a major source of revenue and the fundamental basis of a material recovery system. There have been numerous problems with the air separation system.

Most of these problems have been with the primary air classifier, the only prototype piece of equipment in the plant. This unit initially underwent a basic design change in April, 1978 and continual modifications in the material pickup area have been made since that time with moderate improvements in recovery. In June, 1979, the air flow for the material pickup was increased and performance improved. Similar improvements for the primary and secondary air separation systems were noted when the fan capacity for these units was increased. It appears that all of the air separation systems were initially undersized. Based on the split of materials reporting to the light and heavy fractions, there is a question of whether the plant's air separation equipment is primarily a loading dependent process or a material dependent process. Both the light and heavies streams contain the same materials but in different proportions. For example, the light fraction typically contained 60% paper and the heavies stream contained 29% paper while the heavies stream contained approximately twice the quantities of natural and synthetic organic materials (7.6% and 16.8% respectively) as the lights stream. The different proportions of materials suggests that the material properties are being manifested in the physical separation process but the quantity of the same types of materials in both streams suggests that the loading, which varies during processing, may be a significant factor in the separation process. It may be possible to produce a light fraction (or fuel fraction) by selective screening that is equivalent or superior to that produced by air separation.

Problems have been experienced with material jams in cyclone discharge chutes. This problem has been overcome by enlarging the chutes. These

cyclones have a free discharge and there have been problems balancing the air discharged out of the bottom of the cyclone with that processed through the baghouse; the air distribution also changes under load. A free cyclone discharge appears preferable to one with a rotary valve because of the potential for material jams in the valve.

There has been no problem of material deposition in the primary pneumatic conveying duct. Material deposition in the secondary pneumatic conveying duct has been minimized since the air flow rate was increased.

**Ferrous Recovery**

The ferrous recovery system is important to a material recovery system because of the ease with which the ferrous metal can be recovered and the existence of markets capable of readily using the recovered material. In the Experimental Plant, the electro-magnetic recovery of ferrous materials has been relatively trouble free. Some apparently recoverable ferrous metal at times is missed by the magnet; the reason for this has not been clearly established although the burden of material on the feed conveyor or the position of metal on this conveyor may be contributing factors. The maximum weight of metal recoverable, in a single piece, has been determined as approximately 2 kilograms. Recovery of a greater single weight would require a magnet of greater strength or reduced clearance between the magnet and the feed conveyor. Reduced clearance is not possible because of the burden of material on the feed conveyor.

The remaining portion of the ferrous recovery system has performed poorly and major process changes are scheduled. The ferrous shredder was incapable of surviving the severe duty both because of the size of some of the ferrous metal recovered and because the capacity of the shredder was undersized when receiving acceptable material. Hammers were repeatedly broken making continued operation economically impractical. The increase in bulk density by shredding was negligible; shredded ferrous typically had a bulk density of 475 $kg/m^3$ compared to 420 $kg/m^3$ for the feed material. An attempt to increase the bulk density by reducing the grate size in the shredder was unsuccessful and resulted in more rapid damage to the shredder hammers.

The ferrous apron conveyor has performed well except when overloaded with excessive quantities of ferrous metal. The $45^{\circ}$ angle of this conveyor is considered excessive; when heavily loaded, material tumbles back down the conveyor, occasionally bouncing over the raised sides.

The ferrous storage bin has been ineffective because of extreme difficulty in loading material out of a filled bin. Material is now routinely passed through the bin into a 31 cubic metre bin which is also used for shipping. Shredded ferrous metal bridged in the ferrous storage bin and this problem is worsened by the presence of strapping and wire.

The air pickup over the ferrous apron conveyor does remove loose paper and other light contaminants in the ferrous. However, physically trapped materials, especially film plastic and rags, are not generally removed. The quality of the ferrous product containing these materials has been of concern to the Ministry's customers and potential customers. Loads of ferrous have been rejected for visually excessive contamination. Although this problem has been infrequent, the market potential and selling price are jeopardized by such incidents. A system to burn off organic contaminants has been ordered. Until this unit is installed, excessive contamination will be manually removed. The recovered ferrous metal typical contains 1.1% moisture and, on a dry weight basis, 97.3% ferrous metals. The remaining 2.7% is considered contaminants and contains film plastic, rags, non-ferrous metals, and fines; much of this material is physically trapped in the ferrous.

**Screening**

Most of the problems with the trommel screen have been with the drive system. The trommel screen has had a recurring problem of gear box failure. A total of eight gear boxes were replaced until gear boxes of a larger capacity were installed; no further problems were experienced with the larger units. The drum has dropped out of alignment causing a bearing failure; no further problems were experienced following re-alignment. Occasional electrical overloads of the drive motor have occured when attempting to restart the screen when it contains material. There have been some problems with material spillage at the feed end but minor modifications to the feed chute and the end of the trommel have minimized these problems. The outer shell of the trommel has likely been the

key factor in precluding problems of dust and spillage from the screen itself. A contained screening system is advisable for processing solid waste. Typically the trommel feed material has 37% greater than 19mm, the screen opening size, while the trommel oversize material has 55% greater than 19mm. The trommel fines are 99.8% less than 19mm. The calculated screening effectiveness is 52%.

### Secondary Shredding

The secondary shredder originally designed for an average rate of 13 tonnes per hour with a capacity of 19 tonnes per hour has been a rate limiting process for the resource recovery system. Even at low process flow rates of approximately 7 tonnes per hour the shredder drive was initially overloaded. Removal of a grate resulted in material handling problems in downstream equipment. The shredder grates had to be relieved by substantially increasing the open area to achieve acceptable throughput. Further evaluation of throughput capacity and grate design will be undertaken in future. Preliminary indications are that the secondary shredder drive should likely be similar in size to the primary shredder; the lower throughput requirement is offset by the need for greater size reduction.

### Storage and Loadout

Storage bins for the two fibre fractions, ferrous metal, trommel screen fines, and process rejects were initially designed to allow for temporary material storage to accommodate loadout operations. Problems with bridging in the three small storage bins for ferrous metal, trommel screen fines, and process rejects have resulted in the storage function of these bins being discontinued. Material is discharged directly through these bins to 31 cubic metre shipping bins. Material handling problems with each of the three materials indicate that any attempts to store and retrieve these materials, except with mobile equipment, will likely be unsuccessful.

The storage bins for the two fibre fractions have performed well. The loadout capacity of these bins has not been established because of insufficient capacity of the slipstick vibrating conveyors receiving material from the bins. Additional processing and loadout problems occurred over a six week period when the gear drive for one of the slipsticks failed and the organic bin had to be bypassed. Most of the loadout problems are attributable to the slipstick

conveyors and regulation of the fibre bin discharge rate. The rate of material flow in the slipstick conveyors cannot be controlled. Control of feed rates to lower capacity units such as the incinerator and the composting system has had to be accomplished by altering the discharge gate size opening to ensure that an excess of material is not fed. Most material jams in the incinerator and compost feed systems are the result of an excessive feed rate. The larger capacity equipment, the baler and the compactor, have not been tested to their capacity because the slipstick conveyors are limiting. The design capacity of the conveyors was 54 tonnes per hour at a velocity of 9m/min. while the observed capacity was approximately 10 tonnes per hour at a velocity of approximately 2m/min. The reason for the lower velocity may be the ability of the material to absorb energy rather than be moved by it, i.e. similar to that for other vibrating conveyors. Part of the capacity problem is due to the bulk density of the material being lower than originally anticipated, approximately one-half of the design estimate. Another reason may be the nature of material travel on a vibrating conveyor, i.e. that material seeks its own level in motion on the conveyor and can not be conveyed at a greater depth. Modifications to improve the conveyor performance are being pursued with the equipment supplier.

**Solid Waste Fired Incinerator**

The original problems of material burnout and heat recovery for the solid waste fired incinerator remain to be solved, although some improvement in performance has been realized since startup. This improvement has been achieved by modifications to the incinerator and the controls, increased operating maintenance, and opertion at a considerably reduced feed rate.

The solid waste fired incinerator in the Experimental Plant is of a starved air design consisting of a lower starved air gasification chamber and an afterburner section where complete combustion of the lower chamber gases occurs. Hot gases from the afterburner are drawn through a heat exchanger to produce hot water for plant heating. This type unit was first used elsewhere for incineration of raw refuse. The shredded fibre used as fuel in the ERRP is considerably different in character than raw refuse, e.g. more homogeneous in particle size distribution and much smaller in size. When fed into the unit, the material remains in a continuous block, thus exposing a relatively small surface area to the high temperature environment. The material is also self-insulating,

further adversely affecting the gasification rate. The net effect has been poor burnout, especially when the design feed rate is attempted. An additional air header added in the centre of the gasification chamber in September, 1978 improved burnout by supplying air from within the fuel charge. Further modifications to the unit (removing one of the afterburner blowers from service, restricting the barometric damper, and increased maintenance) in March 1979, improved the performance, but high feed rates still resulted in burnout problems.

The design temperature rise across the unit's heat exchanger has never been achieved at the unit's design water flow rate. Reasons for poor performance have still not been fully defined but contributing factors include fouling of the heat exchanger tubes and suspected low gas flow over the tubes.

The need for additional modifications to upgrade the design of the unit to a current model status was identified as a means to improved performance. The key features of these modifications include the addition of a step in the botom of the refractory lined chamber to tumble the solid fuel to promote burnout and the addition of a filter and air dryer for the soot blower air nozzles. The supplier was scheduled to undertake these changes prior to the 1979-80 heating season; but this work was not carried out. The possibility of a blocking valve in the stack to direct all combustion gases through the heat exchange was suggested but later discounted (by the supplier) in favour of the modifications listed previously.

The ash removal system has not worked satisfactorily. The ash contains large pieces of clinker which could not be removed by the pneumatic ash conveying system. The ash that could be pneumatically conveyed rapidly destroyed the fan for this system. The use of the pneumatic ash removal system finally was abandoned in favour of a manual removal in a bin. The ash will continue to be removed in this manner until a suitable alternative is found.

Material feed to the incinerator has also given problems. Originally many material jams occurred in the screw conveyor feeding the charging hopper because of surges in the flow of material from the distributing vibrating conveyor. A reduction in the gate opening size minimized these problems.

Further evaluation of the unit will be made.

## Compost

The compost system was the last part of the resource recovery system to be completed. Following repairs to the auger gearboxes on initial startup in June, 1978, efforts have been made to achieve the design throughput of 45 tonnes per day (single shift). These efforts have been unsuccessful to the end of September, 1979, because of operating problems, delays because of system modifications, and downtime because of problems in other areas of the plant. Most of the operating and equipment problems have, so far, been with the composting feed system rather than the digester itself.

Air discharged from the feed system baghouse was laden with dust, creating nuisance problems in the composting building. Because of the combination baghouse - cyclone feature and the positive pressure conditions, a rotary valve had to be added to the bottom of the cyclone. This rotary valve was installed in November 1978. Because of excessive wear on the pneumatic conveying fan, the fan was relocated, in May 1979, to the baghouse discharge side of the cyclone to avoid using the fan for material handling. The principal material handling problem has been conveying the wetted feed material from the pugmill to the digester in the vibrating slipstick conveyor. This conveyor, designed to convey 14 tonnes per hour, has not been able to convey more than 2 tonnes per hour. Although there was a slight improvement in conveying capacity following modifications to the slipstick drive in April 1979, it was insufficient to achieve system capacity. The slipstick conveyor was replaced with a belt conveyor in September 1979.

Initial operations indicated that the compost product contained an excessive quantity (visually) of non-biodegradable materials (plastic, rags) which made it aesthetically unattractive. Tests were conducted to select a screening system to remove this material. A twin deck vibrating screen installed in March 1979 has produced an acceptable product. Screen blinding and screen cleaning have been operating problems that are under evaluation; a different type of screening medium will be investigated.

Early operation also confirmed the need for a cover for the digester and an exhaust system to draw off the process gases. Free discharge of the water

saturated gases produced a dense fog in the building. It is unlikely that oxygen levels would be depleted to a level sufficient to create a safety hazard within the building, but external discharge of the digester exhaust gases also precludes this possibility.

There was initially a problem in the digester from composted material bridging over the discharge openings in the centre. All of the central discharge weirs had to be removed to overcome this problem. Whether this solution is adequate remains to be established when the digester is operated at capacity. Other problems relating to material flow within the digester have been experienced. At times, material builds up at the periphery below the feed screw conveyor. The bridge speed has been increased to alleviate this problem and at times the bridge is rotated without feeding to clear the feed area. These material flow problems will be reviewed with the equipment supplier.

Process operation of the composting system has been erratic because of the difficulties with both the digester feed system and automatic process controls. The composting system was originally supplied with automatic controls to regulate the temperature and oxygen content of the composting material. The control system when tested was found to work in principle as designed. However, the reliability of the oxygen meter was totally unacceptable making routine use of the automatic controls impossible. Problems were experienced with the wiring for the temperature controls because of corrosion problems from the moist environment below the digestion tank. In April, 1979, the probe system for the automatic controls was sheared off by the digester augers when the drive motor to retract the probes failed. Replacements probes had not been received by the end of September, 1979, so that further testing and corrective action for the automatic controls was delayed. An additional interlock system to preclude damage to the control probes will be installed before the probes are put in routine operation. A different type of oxygen meter will be tested and installed, if suitable.

In the absence of the automatic controls, the process conditions had to be monitored manually by Ministry staff and process changes made accordingly. The principal process variable has been the air flow rate. An attempt has been made to admit sufficient air to maintain aerobic thermophilic conditions.

Operating problems and the frequency of manual measurements have resulted in less than desirable control of process conditions; process adjustments were generally made to correct an unfavourable condition after it has been established rather than controlling an unfavourable trend as soon as it started. Indications are that the processing equipment should be capable of providing properly controlled conditions for composting following repairs and modifications to the automatic controls.

## PRODUCTION PERFORMANCE

### Plant Availability

During the period April 19, 1978 to September 30, 1979, a total of 366 working days were available for operation of the resource recovery plant. As the plant was operated on only 241 days during this time, overall plant availability was then 66%. However, it should be recognized that for most of the period under consideration the plant was in the shake-down or start-up phases of operation. The plant was down on a total of 125 days because of equipment problems, operating problems, or scheduled repairs. A total of 43 lost days were directly attributable to explosions in the primary shredder. Another 16 days were lost as scheduled downtime to permit the installation of explosion vents for the shredder. An additional 35 days were lost because of repairs to the primary shredder motor. Five additional days were lost as a result of internal parts of the primary shredder coming loose during operation. The remaining lost days were due to fires, equipment failures, operating problems, and scheduled downtimes for items such as calibration of the weighbelts, retro-fitting of the fire protection systems, and maintenance.

During this period, most of the plant downtime was unscheduled with planned plant shutdowns only accounting for 57 days.

A breakdown of all plant downtimes is shown in Figure 6.

### Process Availability

The 241 working days during which the resource recovery facilities were in operation translate into 1752 hours available for processing refuse. Of this time available, the resource recovery facilities were actually in operation for a total of 908 hours, corresponding to an overall process availability of 52%.

In considering downtime recorded during operating hours, problems associated with the primary shredder discharge conveyor accounted for the most downtime (90.6 hours). As indicated earlier, these problems resulted from the inability of the vibrating conveyor to move material reliably, frequently resulting in material jams that required considerable time to free the compacted material. Because of the cost and downtime that would be associated with replacement of this conveyor, attempts were made to minimize downtime by

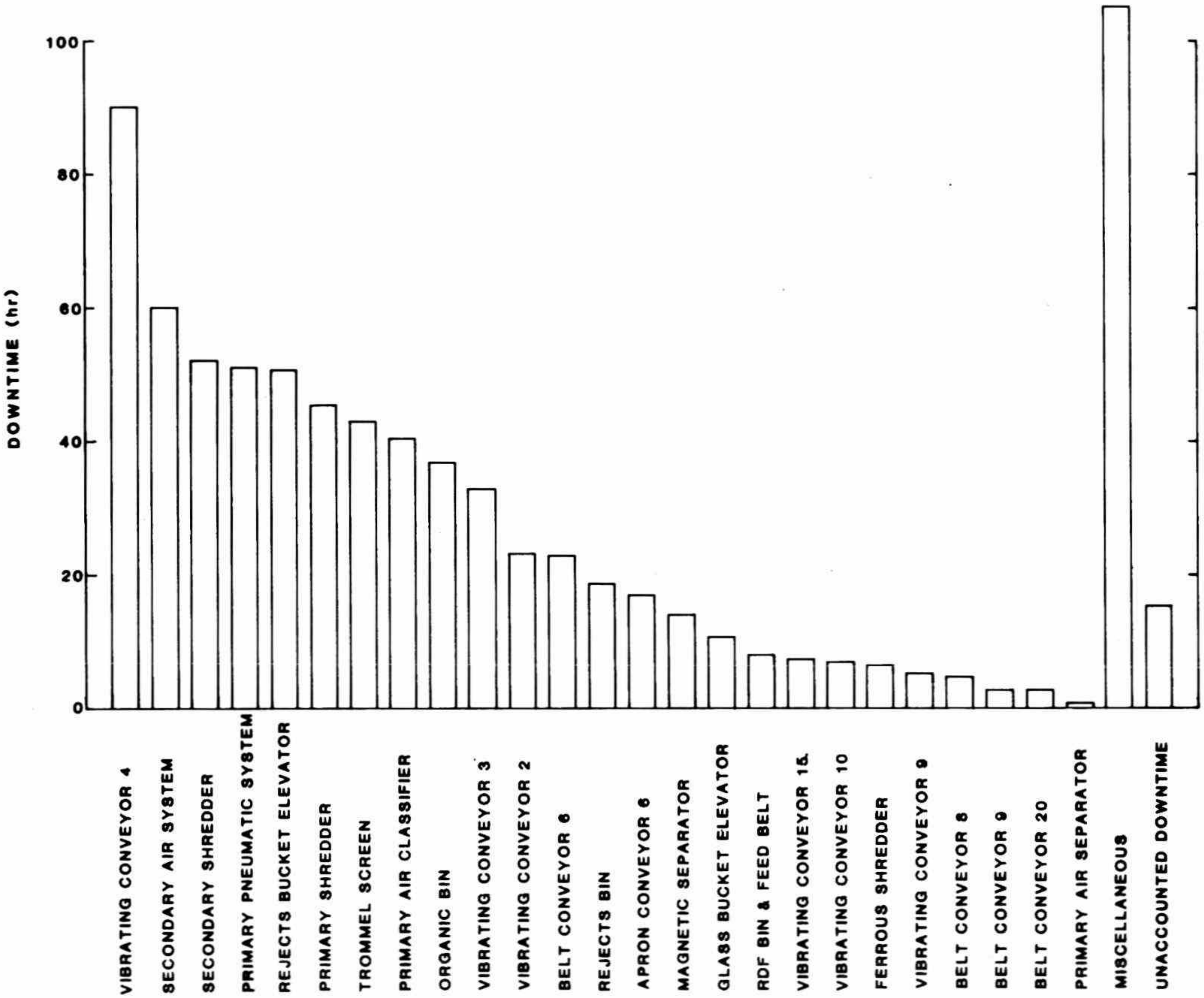


Fig. 6 - Equipment Downtime

changes to operating procedures and adjacent pieces of equipment rather than undertaking replacement of the conveyor.

Table 6 summarizes the major problem areas encountered during the shake-down and start-up phases of the resource recovery facilities. Also listed in this table are the remedial actions taken, if any, to reduce or eliminate the problems. Most of the other processing equipment was the source of downtime only from isolated incidences of material jams, miscellaneous delays to check systems or from problems that could be resolved by relatively minor modifications.

The progress in production performance over the period of this report is shown in Figure 7. In this figure, gross production correlated well with the processing rate during initial shake-down and start-up. However, later on a marked increase in the processing rate did not result in a similar increase in daily tonnage processed. Obviously, when the production processing rate was increased either new problems arose or existing problems intensified. Another restraining factor in attaining acceptable processing rates and daily process tonnages was the three major explosions encountered in the primary shredder area. As shown in Figure 7, little gain or even losses were experienced in processing productivity immediately following the explosions in December, 1978 and March and April, 1979.

The design processing rate of the resource recovery system was 36 tonnes/hour, a rate that was obtained both in July and August, 1979. However, it should be recognized that the nature of resource recovery processing facilities do not allow extrapolation of the basic design processing rate over an entire 8 hour working shift. It is generally felt throughout the industry that a processing availability of approximately 80% is likely to be the maximum attainable. A realistic daily process tonnage for this particular plant is then approximately 230 tonnes/day. This design production figure was only exceeded once during the period of this report.

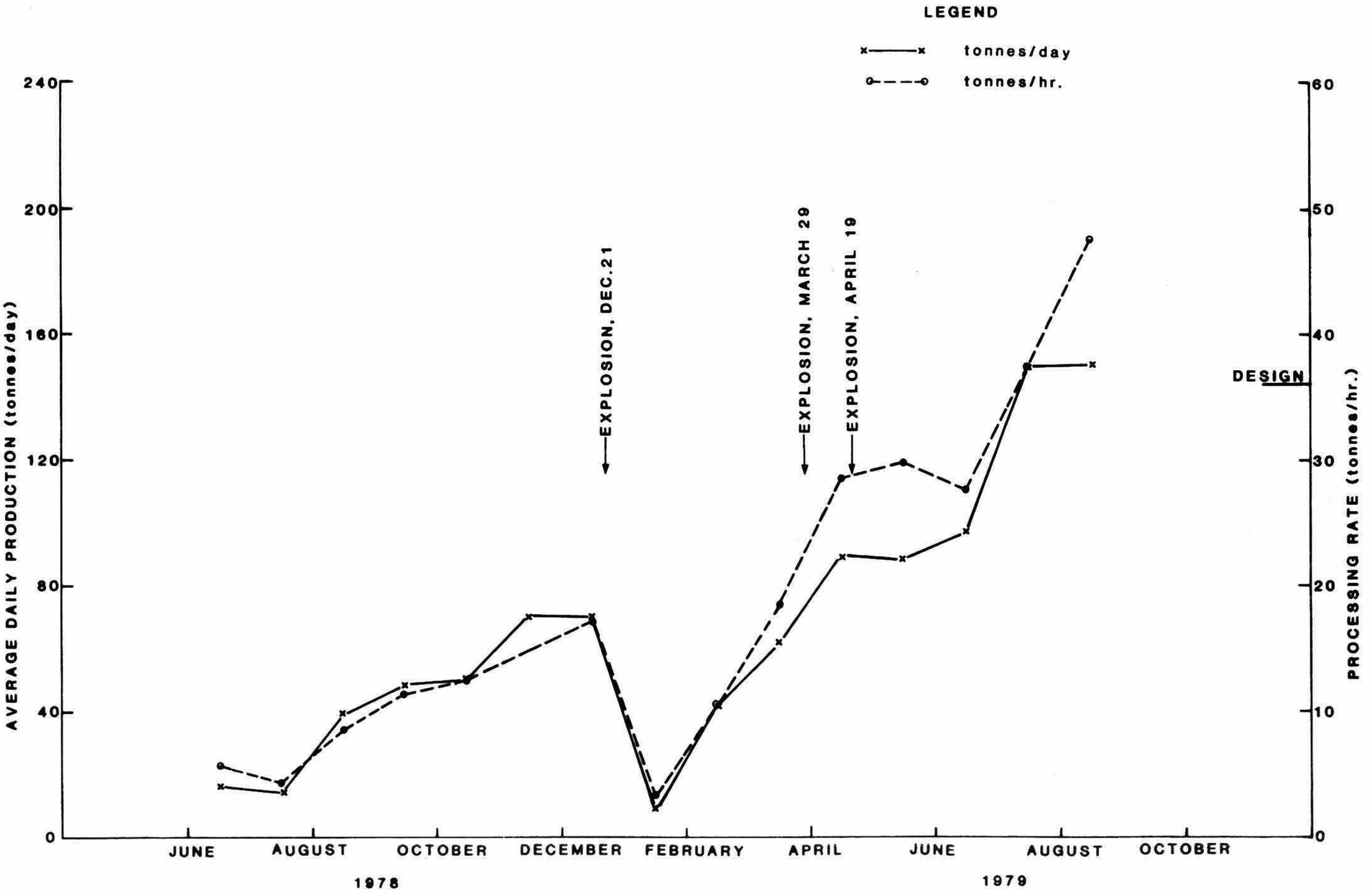


Fig. 7 - Production Performance

## TABLE 6

## MAJOR PROBLEM AREAS

| ITEM | REMEDIAL ACTION |
| --- | --- |
| - Material jams in primary shredder discharge conveyor. | - Review and modification of operating procedures |
| - Material jams at secondary air separator pickup. | - Increased fan capacity |
| - Non-performance of ferrous shredder. | - Removal of shredder from system |
| - Gearbox failures on trommel drive. | - Use of heavier duty bearing units |
| - Material jams in reject system. | - Enlarged feed chutes |
| - Primary air classifier performance | - Increased air flow and continuing investigation |
| - Material jams and fires in primary shredder feed conveyor | - Change in operating procedure to minimize fire effects; the $90^{o}$ change in material flow expected to continue to contribute to material jams |
| - Material jams in ferrous apron conveyor while destroying licence plates. | - Investigating other means of handling plates |
| - Fires and explosions | - See Reference 3 |

### Operating and Maintenance Costs

The operating and maintenance costs for the resource recovery operations over the period April 1, 1978 to Sept. 30, 1979 are summarized in Table 7. As the plant was mainly in the start-up phase and did not attain steady state operation during this period, the determination of costs per tonne processed is of little significance. However, the distribution of costs within processing areas and the general areas of maintenance expenditures are significant.

**TABLE 7**

**OPERATING AND MAINTENANCE COSTS - RESOURCE RECOVERY**

| ITEM | AREA 32 | AREA 40 | AREA 50 | TOTAL |
|---|---|---|---|---|
| Wages and Benefits | 114,658.05 | 19,488.37 | 125,804.90 | 259,951.32 |
| Operating Supplies | 994.24 | 6,491.86 | 25,337.90 | 32,824.00 |
| Electricity | 5,577.98 | 41,967.55 | 51,529.23 | 99,074.76 |
| Allocated Expenses | 12,904.55 | 122,338.84 | 143,789.31 | 295,313.19 |
| TOTAL | 150,415.31 | 190,286.62 | 346,461.34 | 687,163.27 |

Staffing within Area 32, the start of resource recovery includes an area foreman, one-half of the receiving floor complement, spotter and front-end loader operator, the primary shredder operator, and three utilitymen for removal of hazardous and non-processable materials as well as salvage of corrugated cardboard. Originally only one utilityman was provided for hazardous material removal. Staffing for this function was increased with each explosion in an attempt to eliminate flammable and highly combustible materials from the shredder feed stream. Even with this intense surveillance, it was impossible to totally eliminate these materials from the processing stream. Consequently, staffing for this activity will be reduced to a complement of two.

The staffing in Area 40, the primary shredding and air separation/classification area, consisted of one man involved primarily in housekeeping duties, with a secondary responsibility of clearing jams and observing material flow in critical areas. During processing periods, all staff were prohibited from entering the primary shredder area itself.

The operating staff in Area 50, downstream processing excluding energy recovery and composting, included an area control operator, area floor man, storage load-out operator, baler operator and two utilitymen. It is interesting to note that wage expenditures for the initial processing activities were of the same order as for downstream processing activities. It appears unlikely that a municipal resource recovery facility would incorporate many, if any, of the downstream processing facilities found at the ERRP. Consequently, labour expenditures in this area would be greatly reduced in a municipal plant; likely such costs would be limited to providing for bulk load out of the remaining "heavy" fraction.

The operating and maintenance costs for the heating services area, Area 60, are shown in Table 8. This area includes the starved-air incinerator with heat recovery, supplementary gas-fired boilers and domestic hot water supply. This area is staffed by one person, one shift per normal working day. A stationary engineer is not required. Experience to date has indicated that full time supervision would be required if the incinerator were to be operated twenty-four hours per day. Such staffing would primarily be required in the event of feed system malfunction and the high fire risk associated with such a malfunction. The need for manual ash removal also results in a significant labour requirement with this particular type of incinerator.

**TABLE 8**

**OPERATING AND MAINTENANCE COSTS FOR INCINERATOR AND HEATING SYSTEMS**

**AREA 60**

| | |
|---|---:|
| Wages and benefits | $30,330.69 |
| Operating Supplies | 2,667.07 |
| Natural gas and electricity | 124,557.13 |
| Allocated Expenses | 8,642.63 |
| Total | $166,197.52 |

When operating difficulties with the starved-air incinerator have been resolved, an assessment of the economic feasibility of 24-hr. operation of this unit will be made. As reported earlier, present difficulties include: lack of burn-out, inadequate ash removal and ash handling facilities, and poor heat recovery.

The composting system (Area 70) did not start-up until June, 1978. Operating and maintenance costs for this activity are shown in Table 9. Staffing for this area also involves only one person, a compost operator. Major expenditures within the "Allocated Expenses" category were for "retro-fit" items such as replacement of the tubular slipstick conveyor with a rubber belt conveyor and relocation of the cyclone/baghouse fan to the exhaust side of the baghouse, thus eliminating problems associated with the material handling fan.

**TABLE 9**
**OPERATING AND MAINTENANCE COSTS FOR COMPOSTING**
**(AREA 70)**

| | |
|---|---|
| Wages and benefits | $20,196.96 |
| Operating Supplies | 5,069.80 |
| Electricity | 9,296.70 |
| Allocated Expenses | 38,873.50 |
| Total | $73,436.96 |

At the end of the period covered in this report, April 1978 to September, 1979, the composting system was still not functioning adequately with the major problem area being material handling prior to entering the digester.

Total expenditures of the maintenance department are shown in Table 10. All maintenance, modification and retro-fit expenditures are made through the maintenance department. Also included in this category are expenditures for site and building maintenance. Staffing for the maintenance department is shown in Table 1. During the period under consideration in this report, there was an apparent need for increased housekeeping staff.

## TABLE 10

## MAINTENANCE DEPARTMENT EXPENDITURES

## (AREA 80)

| | |
|---|---|
| Wages and benefits | $294,888.32 |
| Parts and Materials | 155,816.48 |
| Operating Supplies | 75,668.80 |
| Outside Services | 256,522.14 |
| Miscellaneous | 12,491.18 |
| Total | $795,386.92 |

Administrative costs are shown in Table 11. Salary expenditures are for the plant general manager, secretary/receptionist, and part-time clerical assistance.

## TABLE 11

## ADMINISTRATIVE EXPENDITURES

| | |
|---|---|
| Salaries and benefits | $90,161.28 |
| Administration Expenses | 27,916.97 |
| TOTAL | $118,078.25 |

## ASSESSMENT

In reviewing the performance of the ERRP over the initial 18 months of operation, one of the key conclusions that must be made is that shakedown and system start-up for such facilities requires considerable time. While approximately 15 months were required in this case, it is difficult to envision any facility of this type completing this phase in less than 10 to 12 months. Similar start-up times have been experienced at other resource recovery facilities on this continent.

When estimating the plant capital cost, provision of adequate retro-fit funds must be included in the overall capital estimate. Retro-fit expenditures at the ERRP were approximately 3% of the initial capital cost, although for budget purposes probably a 5% figure should be used. This retro-fit budget figure is exclusive of normal contingency estimates included in construction contracts. Perhaps as the state of the art of the design and construction of resource recovery facilities improves, the need for such expenditures will be reduced.

### Unit Operations

The material separation operations have produced products of the nature expected in the initial design. However, the actual material separations are not as effective as initially expected, and of even greater importance is the need for recognition of the practical limitations of such unit operations. Some examples of such limitations include:

- certain materials such as carpets and hardened steels cannot practically be shredded,

- shredded products may have a dimension larger than the grate opening,

- under certain conditions, material considered as a "light fraction" will report to the heavy stream,

- some ferrous metal reports to the light fraction,

- all ferrous metal is not recovered by magnetic separation,

- industrial screening operations do not allow for complete removal of fines.

In reviewing the application of air classification, one aspect that must be noted is that the separation operation and the conveying system to remove material are combined elements. Optimum performance of both elements may not be readily attained since the volume of air required for pneumatic conveying may not necessarily be the same as that required to achieve an optimal material separation of a light fraction by physical properties. The performance of the air separator may therefore, vary under different loading conditions giving rise to three basic conditions:

1. Underloaded - the pneumatic conveying air exceeds that required for physical separation resulting in excessive pick-up of heavy material.

2. Properly Loaded - the pneumatic conveying air is the same as that required for physical separation resulting in an optimal separation.

3. Overloaded - the pneumatic conveying air is less than that required for physical separation, resulting in poor recovery of the light fraction.

The particle size, shape, moisture content, and density are all factors in physical separation. Recognizing these numerous parameters that affect the performance of a separation operation, it is then unlikely that properly loaded conditions will prevail constantly during normal operations. Only a uniform loading of a consistent feed material would result in a consistent product quality. In view of such constraints, fine tuning of air separation equipment to achieve a particular product quality does not appear practical. Indeed, it is quite likely that a product similar to that produced by air separation can be produced by some other physical process, such as selective screening. In any event, selection of a separation process and the resulting product should take into consideration the ultimate end use of that particular product.

Finally, design conditions must recognize the interaction between unit operations and that the performance of downstream equipment may be dependent on performance of upstream equipment. Recognition of these two

factors is essential when a system approach is taken to the facility design. The performance of the entire system may be adversely affected by the capacity performance of an individual piece of equipment. Similarly, downsteam equipment may be affected by the degree of separation that an upstream operation attains. In all cases, the design of a resource recovery facility should recognize that a wide range of operating conditions may exist both with respect to initial feed material and, probably more significantly, internal material flows within the overall system.

**Material Handling**

Undoubtedly conveying is the most common method of material handling or transport, whether it be apron, belt, vibrating, drag, or screw. Within the ERRP, conventional vibrating conveyors and slipstick conveyors were the source of many problems, both in terms of conveying capacity and material jams. The conventional vibrating conveyors had a great tendency to jam once the slightest resistance to the material flow was encountered, undoubtedly stemming from the lack of a positive displacement capability. Both types of vibrating conveyors were generally incapable of transferring material at design rates. Screw conveyors and bucket elevators have been the source of some material jams but have not required modification or replacement. Belt conveyors have been generally trouble free and are recommended over all other conveyor types unless a specific application dictates the use of another type, e.g. the use of a steel apron conveyor for raw refuse to avoid wear problems and to withstand impact loads.

While pneumatic conveying systems have generally performed well, preliminary results indicate that such systems may have high maintenance costs as a result of excessive wear. In the event that maintenance costs associated with air separation and pneumatic conveying systems are indeed excessive, it may again be more appropriate to use a selective screening system to produce a light fraction.

No problems were encountered in the use of the live bottom storage bins handling the light fraction and the organic fraction, although it has not yet been determined whether the discharge mechanisms can deliver material at the design rates.

Because of various problems with the small storage bins provided for ferrous metal, trommel fines, and process rejects, it is recommended that interim storage facilities of these products not be provided and the materials be discharged directly into shipping bins.

Another major consideration when considering material handling systems within a resource recovery facility concerns chutes and enclosures. All such chutes and enclosures through which material passes should be designed as large as possible. The problem with restrictive chutes becomes further compounded when material fails to report to its proper fraction. A prime example of this type of problem occurs when processing wet refuse. In this case the light fraction is significantly reduced and material flow in the heavy stream may be 30 or 40% in excess of anticipated loadings.

**Environmental Considerations**

The major environmental concerns associated with the dry processing of solid wastes are dust, spillage, and fires and explosions. Based on the experiences at the ERRP, dust problems in a resource recovery facility could likely be more readily controlled by making provision for retro-fitting dust collection systems rather than incorporating such systems in the original design and construction. In suggesting this approach, it is recognized that rectifying planning and design errors and omissions during or after construction is costly. However, since the nature of dust collection problems associated with solid waste processing is relatively ill defined at present, successful application of recognized control technology is then best deferred until a thorough assessment of the problem is carried out. Much of the original dust control system in the ERRP is now no longer in use because dust conditions were not a problem in a particular area or the problem was beyond the capability of the original control system.

Material spillage should not be a serious problem if adequate access is provided below conveyors and other areas of spillage to facilitate clean-up. Good housekeeping should be a routine practice for health and aesthetic reasons and to minimize potential hazards from fire.

Adequate loss control measures are available to minimize damage from fires and explosions associated with the processing, primarily shredding, of solid waste. The extensive modifications and additions to the processing systems for loss control for fires and explosions were made as a result of practical experience and are fully detailed elsewhere (3). Two of the more significant measures include isolation of the primary shredder from operating personnel and adequate training of operating staff in fire and loss control procedures.

## RECOVERED MATERIALS AND MARKET DEVELOPMENT

Most of the materials recovered from the basic processes were generally of the quality initially expected, although the high percentage of commercial/industrial waste processed undoubtedly influenced the character of the recovered materials. A summary of the overall analytical results for the principle products is presented in Table 12. Table 13 indicates the product distribution as a weight percentage of total refuse processed. While these data characterize the materials recovered, they must be viewed as primarily raw materials and the potential for further processing recognized. The need for such further processing depends upon the particular market and the customer's quality requirements.

All marketing and market development efforts for products recovered at the ERRP are conducted by the Waste Management Branch of the Ministry of the Environment.

Perhaps the most reliable separation process in terms of product quality is manual separation, used at the ERRP for recovery of corrugated cardboard. Since this approach is obviously labour-intensive, its practical application should be limited to high value commodities and cannot readily be extended to recovery of other materials. The success of manual separation for corrugated cardboard recovery is due to the high percentage of commercial-industrial wastes received, the size of material available for recovery, and the ease of recognition and removal of acceptable material from the waste stream. In addition, proper training of staff involved is essential. Manual recovery of ferrous material, for example, would be impractical.

In the case of corrugated recovery, this commodity has the highest unit value of any stream recovered at the plant. Market demand for this material is quite firm and the product is one that is well established within the secondary materials industry. Purchasers of this ERRP product have included: Trent Valley Paperboard Mills, Dominion Recycling, Atlantic Packaging, and Domtar.

Recovered municipal ferrous scrap (MFS) represents approximately 5% by weight of the refuse processed through resource recovery (Table 13). Because of

the high fraction of commercial-industrial waste processed from which ferrous is recovered, the ERRP MFS has a relatively low tin content making this material somewhat unattractive to the detinning industry. Although no problems in detinning were encountered, the low tin content was of concern. To fulfill the market development objectives and satisfy the requirements of potential customers for a denser product, some MFS has been baled by a contractor and subsequently marketed by the Ministry. To date there have been no significant metallurgical problems in the use of MFS in either a loose or densified form. The purchasers of MFS have included: Lake Ontario Steel, Metal Recovery Industries, Brown and Boggs Foundry and Machine, and Intermetco. These industries include steel mini-mills, iron and steel foundries, and a detinner.

In some cases, visual appearance is of considerable importance in the customer acceptance of the product. This is particularly true for MFS; even two to three percent organic contamination can seriously impair its marketability, with such impairment resulting from aesthetic non-acceptance rather than technological problems. Considerable effort has been required to gain acceptance of the ferrous product in its present condition, although all MFS recovered has been marketed. A low temperature incineration process to remove organic contamination has been ordered.

At present the reject fraction of the processed waste is considered as a by-product to be landfilled. Since non-ferrous metals report primarily to this fraction, there may be potential for manual salvage of this product. However, preliminary results indicate that insufficient quantities of such metals are present to warrant this approach. The technology of non-ferrous recovery systems, as applied to solid waste processing, has not yet been proven for commercial application.

The major product of the ERRP, expressed as a percentage of the total waste processed, is the light fraction, containing primarily paper and film plastic. This material has approximately one-half the calorific value of coal and has potential for use as fuel (refuse derived fuel, RDF) or as a feedstock for low grade paper fibre recovery. The fuel market has the greatest immediate potential with fibre recovery likely one or two decades away. Market development efforts are also proceeding in the use of the light fraction as a mulching agent, insulation raw material, and animal bedding substitute.

# TABLE 12

## PRODUCT CHARACTERISTICS

| Product or Process Stream | Moisture % | Bulk Density ($kg/m^3$) | Particle* Size (mm) | COMPONENTS (Weight % - dry basis) Paper | Natural Organics | Synthetic Organics | Ferrous | Glass | Others and Fines | Calorific Value (J/gm) | Ash (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary Shredder Discharge | 21.6 | 103 | 100 | 49.3 | 10.9 | 9.2 | 6.4 | 0.7 | 23.5 | 15060 | 29.7 |
| Refuse Derived Fuel | 18.6 | 62 | 100 | 60.1 | 3.7 | 7.8 | 0.3 | 0.1 | 28.0 | 16,500 | 23.4 |
| Ferrous | 1.1 | 420 | 100 | --- | --- | --- | 97.3 | --- | 2.7 | — | — |
| Organics | 22.1 | 123 | 100 | 51.4 | 12.0 | 9.1 | 0.4 | 1.6 | 25.8 | 16,950 | 22.7 |
| Trommel Fines | 28.9 | 246 | 19 | --- | --- | --- | --- | --- | --- | --- | 40.9 |
| Compost | 42.7 | 513 | 6 | --- | --- | --- | --- | --- | --- | --- | 32.2 |

* 95% less than size shown

## TABLE 13

## RESOURCE RECOVERY PRODUCT SPLIT

| Product | Percentage of Input |
|---|---|
| Refuse Derived Fuel | 46.3 |
| Organic Fibre | 34.0 |
| Ferrous | 5.5 |
| Trommel Fines | 5.8 |
| Rejects | 8.4 |
| TOTAL | 100.0 |

The largest immediate fuel market for RDF is the cement industry, wherein this material has potential for use as a supplementary fuel, replacing a percentage of the normally used fossil fuel. The Ministry of the Environment has a full scale joint demonstration project underway with Canada Cement LaFarge Limited at the Company's Woodstock facilities.

The trommel screening operation within the ERRP processing system was originally installed to provide a glass-rich fines fraction. To date this fraction has contained relatively little glass as indicated by the total ash content of only 40%. While these results are partially attributable to the type of waste processed, it appears highly unlikely that this fines fraction has or will have any commercial value.

Perhaps one of the more interesting plant materials from a market development perspective is the compost product. This material, produced from organic waste and wastewater sludge, has market potential as a soil conditioner rather than a fertilizer. The present market development efforts of the Ministry are directed at usage of this compost in quarry rehabilitation, embankment stabilization, conservation areas, and horticultural applications.

The original compost product was considered unacceptable due to the presence of large pieces of plastics and rags. A screening system retrofitted in April, 1979 has been effective in producing an acceptable product. There have been some operational problems with the screening equipment (screen blinding, difficulty in screen cleaning), and efforts are being made to reduce these problems without compromising product quality.

## GENERAL

The facilites of the Experimental Plant have been used by other Ministries to perform services consistent with the plant's capabilities. Confidential records have been received regularly for destruction in the solid waste fired incinerator. A total of 275 tonnes of returned or overissue license plates were received for destruction by shredding. Outdated publications have been received for paper recycling and baled for marketing.

The Experimental Plant has served as a study site to determine occupational health hazards associated with the resource recovery industry. Additional studies in this area will be undertaken in future.

Interest in the Experimental Plant has been demonstrated by continuing requests for tours by the general public, schools, consultants, and government officials. Guided plant tours were conducted for 2,980 visitors during the period April 1978 to September 1979 inclusive. A breakdown of the visitors is shown in Table 14.

**TABLE 14**

**ERRP VISITORS - April 1978 - September 1979**

| Type of Visitor | Number of Visitors |
|---|---|
| Schools | 849 |
| Universities | 348 |
| Foreign: | |
| U.S.A. | 103 |
| Others | 98 |
| General Public | 632 |
| Technical | 553 |
| Government Officials | 339 |
| Media | 58 |
| TOTAL | 2,980 |

To fulfill the ERRP's function as a source of data on resource recovery, samples of the various process streams are taken routinely according to a

sampling programme established to determine both product quality and unit process performance. Analyses of the samples are conducted in the laboratory facilities of the ERRP by Ministry staff. Samples requiring more than the routine solid waste analyses are prepared for analyses by other Ministry laboratories or by external laboratories; typically these samples require elemental analyses.

The analytical capabilities of the Ministry's ERRP staff have been of benefit in providing assistance for market development efforts, either in the preparation of trial quantities of material or performing non-routine analyses.

Ministry staff have provided assistance to the American Society for Testing and Materials by participating in the establishment of product standards and test procedures and by testing new analytical procedures.

Most of the analytical procedures used in the ERRP laboratories have been developed or adapted by Ministry staff from fields related to the product use. The procedures are being continually reviewed as required, to ensure that they efficiently serve to provide data for evaluation of the plant processes and product quality.

Part of the purpose of the ERRP was to serve as a training facility. Staff from another facility have made use of this capability on several occasions to gain practical experience prior to the startup of their own facility. Senior staff from other facilities, either in operation, under construction, or planned, frequently visit the ERRP to review or exchange operating experiences.

## FUTURE WORK

As indicated throughout this report, much of the past effort of Ministry staff has been directed toward resolving problems encountered during shakedown, startup, and follow-up after modifications. Future Ministry efforts will be directed in the following areas:

A. Reports on:

1. Shredding
2. Composting
3. Plant operations from October 1979 to March 1981

B. Modifications of existing plant processes to increase the process efficiency or to improve product quality and evaluation of the modified systems including:

1. Screening of the primary shredder discharge prior to air separation to reduce fines and inerts in the light fraction and to assess the use of screening as an alternative to air separation.

2. Evaluation of the effectiveness of controlled incineration of the recovered ferrous material to remove organic contaminants (unit to be installed) including an assessment of air emissions.

3. Modifications to the solid waste fired incinerator to improve heat recovery and burnout.

4. Repair and evaluation of the metal detectors on plant conveyors.

5. Replacement of the rejects bucket elevator, storage bin, and discharge system with a belt conveyor.

6. Processing the light fraction by further magnetic separation and screening or shredding or both to produce an acceptable material for mulching.

C. Assessment of plant equipment or conditions or of external equipment to improve process performance or operating conditions including:

1. Evaluation of the fibre storage bins unloading rates.

2. Evaluation of the composting system performance under different loading conditions.

3. Evaluation of the compost screening equipment.

4. Evaluation of automatic controls for the composting system.

5. Evaluation of the effect of different air flows in the primary air separator on material recovery and product quality.

6. Evaluation of equipment to densify refuse derived fuel.

7. Evaluation of the potential of non-ferrous metal recovery from the process rejects.

8. Trommel screen performance assessment.

9. Co-ordinating occupational health studies to assess potential noise, dust, and microbiological hazards.

It is anticipated that most of the above work will be completed over the next 24 months. Specific reports will be prepared for major areas of interest. Results of other investigations will be included in periodic reports of plant operations.

## REFERENCES


1. Ahlberg, N.R. and Boyko, B.I., "Research and Development Facilities at the Ontario Centre for Resource Recovery", Proceedings of the 1978 National Waste Processing Conference, The American Society of Mechanical Engineers, New York, N.Y.

2. Ontario Research Foundation, Report No. OHS 78-08-1, "A Study of Dust Levels at the Ontario Centre for Resource Recovery" for the Ministry of the Environment, Province of Ontario, July 1978.

3. Ahlberg, N.R. and Boyko, B.I. "Explosions and Fires - Ontario Centre for Resource Recovery", Proceedings of the 1980 National Waste Processing Conference, The American Society of Mechanical Engineers, New York, N.Y.

## APPENDIX I

## MUNICIPALITY OF METROPOLITAN TORONTO

## NOTICE OF PROHIBITED MATERIALS

An increasing number of private haulers are using our Transfer Stations to dispose of loads containing materials which are either hazardous or cause handling problems. Such materials cannot be accepted at a transfer facility and must be taken directly to the landfill site.

These materials include:

1. Hospital waste, including drugs of any kind.

2. Sawdust or any other dusty or fine material, unless wetted down.

3. Rubber tires in quantity.

4. Long strands of plastic, wire, hoses, or similar material.

5. Flammable, explosive or other hazardous material, including paints and paint thinners.

6. Demolition material.

7. Tree stumps or trunks longer than 4 feet.

8. Waste from abattoirs.

9. Dead animals.

The above list is only partial and is intended only as a guide. Any doubtful material should be checked by calling the Transfer Station concerned before delivery.

We request your co-operation in observing these regulations. A continual disregard for them by any hauler will leave us no alternative but to deny an offender the use of any of our disposal facilities.